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THE EFFECT OF STIMULUS INTENSITY ON THE FATIGUE CURVE FOR REPEATED VOLUNTARY MAXIMAL GRIP STRENGTH CONTRACTIONS

by

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies for acceptance, a thesis entitled "The Effect of Stimulus Intensity on the Fatigue Curve for Repeated Voluntary Maximal Grip Strength Contractions" submitted by Lorne Edward Hasinoff in partial fulfilment of the requirements for the degree of Master of Science.

ABSTRACT

The purpose of this study was to see if a change in an individual's fatiguing rate could be induced by altering the intensity of the subject's performance cue. Each subject was required to squeeze a hand dynamometer as hard as possible on the cue "pull" twenty-five times, once every five seconds. A 700 cycle per second blip was included midway between each stimulus signal to ensure that the subject would keep attending each instruction. A cover story was incorporated in an attempt to initialize pre-task motivational levels.

Eighty subjects were randomly assigned to one of four test groups, receiving only one testing session. The control group received a series of twenty-five identical stimulus signals, each at a constant level of seventy-three decibels. The three experimental groups received exactly the same instructions as the control group, except that they received either a sixty, eighty-six, or ninety-nine decibel stimulus signal on trial sixteen. All instructions were pre-recorded to ensure standardization for all subjects.

Analyses of variance and covariance were applied to the difference score obtained from subtracting the mean of trials sixteen to twenty from the mean of trials eleven to fifteen for each subject. No significant differences were found.

It was concluded that no difference existed between any of the four groups. Hence, an individual's fatiguing rate could not be altered by a change in the intensity of the performance stimulus.

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STATEMENT OF THE PROBLEM

Introduction

Man has associated an increase in muscle strength with exercise since at least the sixth century B.C. At that time Milo of Crotona advocated lifting a baby calf onto one's shoulders daily as a means of increasing muscular strength (1). As the calf increased in weight, so the individual would increase in strength until he reached the limits of his potential strength at which time he would be unable to lift the calf.

A variety of undesired sources of variation such as motor learning, attitudes, motivation, feelings of well-being or discomfort all affect the amount of effort an individual will put into a voluntary exercise. The comments of Ikai and Steinhaus (2:161) are representative of the opinions held by a number of investigators in the field of strength development.

> Our findings appear to support the thesis that in every voluntarily executed, all-out maximal effort, psychologic rather than physiologic factors determine the limits of performance. Because such psychological factors (including pharmacologically induced psychic states) are readily modified, the implications of this position gravely challenge all estimates of fitness and training effects based on testing programs that involve measures of all-out or maximal performance.

Yet in the 1950's many physiologists maintain that in voluntary efforts it is not known for certain whether the force that can be exerted is limited by the capacity of the nervous centres and conducting pathways to deliver motor impulses to the muscle fibers or by the intrinsic contractile properties of the fibers themselves; whether in fact, a voluntary effort can be bettered by maximum tetanic stimulation of the

musculature electrically, or not. Also in fatigue, it was not clear whether tension falls off because the degree of voluntary innervation drops or because the fibers are biochemically incapable of maintaining their contraction (3). This problem was maintained by the semantic misinterpretation of the word fatigue as used by physiologists as opposed to the meaning applied to the word by psychologists. Bartley (4) has clarified some of the misconception by terming the dependent variable work output rather than fatigue.

Nevertheless, it remains well known that the body has reserves which are not under the control of the will and are available for use only under stress, emotional or otherwise (4). Wolfe (5) feels that in a voluntary maximal effort inhibitory influences from the brain limit an individual to approximately fifty per cent of his capacity.

Removal of inhibitions can be affected by fear, alcohol, and placebos. Actually, it is the belief in the potency of the placebo itself that allows individuals to activate the bodily equipment to a super-usual performance.

Margaria and Gualtierotti (6) have suggested that biochemical and physiologic changes due to muscular contribution in itself may be trivial in comparison with other factors mainly of psychological nature that are most responsible for the reduction of performance and for the subjective and unpleasant sensation characteristic of fatigue. These last components are particularly important in activities not involving hard exercise.

The idea of this study was conceived as a logical extension of the brief review presented in the introductory section - to put the phenomena of the voluntary maximal to test using the criterion of grip strength and the motivating agent of an auditory stimulus of changed magnitude.

Statement of the Problem

The purpose of this study is to determine the effect of stimulus intensity on the fatigue curve for voluntary maximal grip strength. Specifically, the following hypotheses are proposed:

(1) that the presentation of an auditory stimulus of different intensities will not produce a change in the pattern of the fatigue curves for grip strength.

(2) that the magnitude of an increase in intensity of the auditory stimulus will not have a predictable effect on the response.

Value of the Study

The usual procedure in studies in the physiological and psychological areas of physical education is to increase the effect of experimental variance and to reduce the effect of extraneous variance introduced by psychological factors. These factors do play an important role in athletic performance, as well as in everyday life, and thus merit study.

The study of psychological factors as nuisance variables dates back to the middle of the nineteenth century when experimental psychology was first becoming experimental. Early investigators in this area were concerned with the study of the average, normal, adult human being. This study was statistical in the sense that investigations sought to describe an average person. Measurements obtained on different people yielded different results, and the main concern was with an average or some other representative measure of central tendancy among the results for a particular group of observers. The pioneer of this era was G. T. Fechner and most of his work went unchallenged until the 1930's when S. S. Stevens

began to question the validity of the Weber-Fechner Law. It was Stevens' systematic study which ultimately led to the present psychophysical law which relates stimulus intensity to stimulus sensation (7). This relationship of stimulus intensity to stimulus sensation has practical application to much of the strength and fatigue testing done in physical education where this form of external motivation is being used.

Delimitation

A human vocal signal was used in preference to a white noise stimulus.

Definition of Terms

Fatigue. "A self-recognizable state in which the individual feels inadequate for his task based on bodily experiences of discomfort, weakness, slowness, et cetera and also upon other cognitive criteria such as feelings of futility, et cetera, and when rightly understood, this state is seen to have a relation to performance, particularly its cost." (4:154)

Placebo. "An inactive substance or preparation, formerly given to please or gratify a patient, now also used in controlled studies to determine the efficacy of medicinal substances" (8).

Double-blind. A situation in which both the subject and the experimenter believe the substance to be pharmacologically active (9).

Single-blind. A situation in which the subject remains naive but the experimenter is aware of the inertness of the substance (9).

Sone. The sone is a unit of loudness. By definition, a simple tone of frequency 1000 cycles per second, forty decibels above a listener's threshold, produces a loudness of one sone. The loudness of any sound that is judged by the listener to be n times that of the one sone is n sones (10).

Intensity Level. The Intensity Level, in decibels, of a sound is ten times the logarithm to the base ten of the ratio of the intensity. The reference intensity shall be stated explicitly (10).

Decibel. The decibel is one-tenth of a bel. The abbreviation "db" is commonly used for the term decibel (10).

Bel. The bel is a dimensionless unit for expressing the ratio of two values of power, the number of bels being the logarithm to the base ten of the power ratio (10).

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CHAPTER II

REVIEW OF THE LITERATURE

Fatigue and Muscular Tension

In the classic sense, muscular fatigue involves large work decrement resulting from massed practice on certain motor tasks--the decreased capacity of a muscle that follows continued or repeated contraction. It seems obvious that muscular fatigue must occur in the muscles, but actually this is true only in a limited sense. The early experiments seemed to indicate that the fatigue breakdown occurred considerably higher up in the nervous system.

The body-process phenomena that seem to be a part of the individual's overall concern even when he is fatigued, are not in themselves fatigue, and cannot be studied as if they were. Dealing with these processes as such is dealing with action at sub-personalistic levels. One of these sub-personalistic levels is the cellular level. Bartley (1) has termed anomalous function of cells impairment. Not only can impairment occur without fatigue, but fatigue can occur without impairment, although sometimes impairment does happen to underlie fatigue, or fatigue induce impairment. Two general outcomes are possible in the human organism:

(1) disorganization occurs at various levels including the personalistic and has to do with the function of cells with each other.

(2) impairment has to do with the condition of cells.

If one believes all action of the organism as a unit depends upon body processes, then all action is dependent upon organization of the component processes. Some systems such as the central nervous system are capable of being organized in almost infinite numbers of ways. Much of

this vast potentiality lies within the normal function of its constituent cells. Hence functional anomaly of cells need not be the first suspicion when the organism as a whole behaves in a unique way, or when it slows down or fails in any performance. Fatigue is one of several forms of disorganization the human may exhibit.

As early as 1890, Mosso (2) found that an "exhausted" finger could be made to respond by electric stimulation (through the skin) of either the muscle or its motor nerve; the implication being that the fatigue occurred higher up in the nervous system. This need not mean that some connections in the higher centres failed through metabolic changes. Actually, muscular fatigue in the intact organism turns out to be due, not to any passive failure of the muscles or its controlling neural paths, but to an active feedback which protects the muscle from overwork (3).

Spearman (4) reported that a person's efficiency at any continuous work, such as finger ergograms, diminishes very rapidly for a period of about two minutes, but then undergoes very little dimunition for hours, until finally there occurs an abrupt drop down to entire impotence. But during all the time that so little dimunition is manifested, a longer and longer rest becomes necessary in order to regain the full efficiency of the beginning; fatigue was really occurring all the time, but in such a way as to remain latent.

Phillips (5) found that the fatigue manifested after ninety minutes of continuous work seemed to fall into three portions. First, there was a large portion, twenty-four to fifty-seven per cent, which vanished as the subject proceeded to a similar kind of operation, but rendered more interesting by being regarded as a test. Such fatigue so lightly dissi-

pated could only be of a subjective sort. Second came the portion of fatigue which resisted the excitement of being tested, but yielded to a change in the kind of operation used for testing. Such fatigue was seemingly objective in nature, but still specific in the sense of not being transferred to unlike operations. Third was the remaining portion of fatigue yielding neither to excitement nor to change. Summing up, Phillips termed subjective fatigue as partly specific and partly objective.

Data obtained under widely different conditions indicate that increments in tension may increase efficiency of performance, have no effect on it, or be actually inhibitory. Freeman (6) did a series of experiments in an attempt to relieve some of the ambiguity of these contradictory results. In one of the experiments, the relationship of motivation to both facilitative and inhibitory effects in the same task was investigated. The results indicated that while tension is a factor normally contributing to the facilitation of work, it may become an inhibitor of precise performance. Tension was notably increased under the conditions of "supermaximal" effort. The instructions for a "submaximal" effort were generally successful. In both these cases, the controls were set by the use of appropriate incentive motivation. Freeman was careful to add that facilitation of any activity depends upon three factors:

(1) Qualitative - the locus of the facilitating activity

(2) Quantitative - the amount or intensity of the facilitating activity

(3) Temporal - the time relations existing between the onset of facilitating activity and the performance under observation.

To obtain the qualitative locus of optimal muscular facilitation, the quantitative and temporal factors must be held constant. If facilitation were defined as the increase of neural action by increased stimulation, the summation of impulses would explain the reinforcement of higher neural arcs by muscular tension.

Pike and Chappell (7) documented information concerning the summation of impulses on the motor horn cells and in the cerebral cortex as well as on the afferent side. Freeman felt that cortical summation of proprioceptive impulses with impulses of other origin occurred in his experiments. The facilitation of selected acts by the preliminary contraction of the reacting muscle groups indicated that summation may also have occurred on the efferent side of the arc. Freeman concluded that optimal facilitation is obtained when the tension is in muscle groups most closely related neurologically to the reacting member and is not the same for all performances.

A study by Bigland and Lippold (8) dealt with the actual motor unit activity during a voluntary contraction. Human muscles were stimulated with square pulses applied locally and via the motor nerve at different frequencies; the tensions being recorded with a strain gauge. The maximal tension produced by tetanic stimulation equalled that developed in a maximal voluntary contraction. The ulnar nerve was partially blocked by pressure at the elbow, and motor unit frequencies were measured during maximal efforts as the tension declined. The frequencies of the discharge were not higher than those occurring when the nerve was normal and the relation between strength of contraction and rate of firing was the same as in the unblocked state. These results indicate that gradation of contraction in the muscles investigated was brought about mainly by motor

unit recruitment except at very low and high contraction strengths.

Josenhans (9) noted that peak performance could only be reached after many training sessions and accompanying improvement was reflected in significant changes in the electromyograph pattern with increased mobilization of motor units.

Psychophysiologic Phenomena

Changes in the motivational level of the subject or athlete during his test or trial alter his performance. Investigators have approached this problem of motivation in a variety of ways.

Josenhans (9) noted the effects of motivation, in the form of competition, on the gain in muscle force resulting from a training program and suggested that motivation may contribute to the gain in two ways:

(1) elimination of inhibitory mechanisms

(2) increased mobilization of motor units.

In answer to the question of how motivation effects the muscle fiber and the increase in muscle force Josenhans explained that "increased motivation most likely mobilizes more muscle tension; and most observers indeed found a significant relationship between training force and gain." (9:320)

Lehmann et al (10) found in experiments with Pervitin that the end-point of any performance is a balance between fatigue and muscular pain on one side, and motivation and will-power on the other. The effect of motivation in the gain in muscular force was attributed to the same two factors as listed above.

Hislop (11) recommends that to obtain the maximum voluntary performance one should select subjects who have a personal interest in the

research rather than a larger, more random group. She appealed for greater cognizance of the role of motivation in voluntary activity. The author emphasized her point by stating:

> Regardless of the exact nature of the substrate mechanisms, it must be acknowledged that the indefinable process of motivation is what permitted man to run his first four-minute mile; and what has led to the statement that 'records are made to be broken.' The desire to excel therefore, should be considered as one of the determining variables responsible for improvement in human voluntary muscular strength. Quantitative estimates of motivation cannot be made but the observations made in this experiment illustrate that its presence can be dramatically demonstrated when such persons are compared with subjects who respond in the usual or 'average' manner. (11:36)

Gorton (12) pointed out that the actual contractile force of a muscle is greater than normally apparent, indicating the instances of fractures due to muscular contraction observed as complications in electric shock therapy. Muscular activity then seldom reaches a maximal nature in testing situations.

As motivation is partially confined by induced inhibitions, many researchers have employed hypnosis as a method to determine the extent of these inhibitions. Orne (13) did a study using "real" and "fake" hypnotic subjects and was unable to distinguish between them using the following tests:

(1) a lighted match applied to the third finger.

(2) forcible flexion of the two terminal phalanges of the little finger.

(3) electrical stimulation of the index fingers.

Interestingly enough, the "fake" subjects flinched less.

Studies by Levitt and Brady (14) and Barber and Calverley (15) have indicated that subjects in the motivated waking state are capable of eliciting performances traditionally associated with the word hypnosis. The

studies of Rosenbaum and London (16) and Slotnick and London (17) showed cases where hypnosis seemed to markedly improve the performance in susceptible subjects while having little effect on unsusceptible ones.

The majority of studies reviewed employed subjects in the untrained state. Populations of this nature are obviously not functioning at or near their potential. The extent that training results in desensitization of inhibitory phenomena represents a limiting factor.

Morgan and Coyne (18) compared the relative effectiveness of stereotyped task motivating instructions, placebo ingestion, and control treatment on strength of grip and weight-holding endurance. The placebo group had significant decrements on both parameters. Since this study was a "single-blind" study, the placebo reaction was difficult to assess. Subsequent personality testing using the Eysenck Personality Inventory (EPI) revealed that five of the six subjects were neurotic extraverts and the sixth subject, while extraverted, was not neurotic.

In a follow-up of the previous study, Morgan, Cooper and Goeckerman (19), using a "double-blind" technique, concluded that extraverts were negative placebo reactors as measured by strength of grip. Significantly different performances were not observed for either group on the muscular endurance task. Estimation of performance following placebo ingestion was not related to personality type.

Johnson, Kramer, and Massey (20) used hypnosis to assess the effectiveness of pre-performance warm-up. All subjects were placed in a hypnotic trance and then half engaged in warm-up activities which were forgotten in the post-hypnotic state. Findings indicated that warm-up may be

a variable related to motivation since it was discovered that no significant performance differences were noted between the two groups in a post-hypnotic test.

Roush (21) had her subjects run through tests on a hand dynamometer, arm dynamometer, and hand-hang apparatus in the waking, hypnotic, and post-hypnotic states. Subjects were given the instructions to ignore pain in the hypnotic and post-hypnotic states. Subjects showed increased performance in all three tests for the hypnotic state. Indications were that this increased performance results from removal of inhibitory influences during the hypnotic state.

Merton (22), using a one-trial experiment, found that a voluntary effort can realize the full tetanic tension of the muscle but this observation was limited to very brief periods of contraction. Out of this it was postulated that one's greatest strength is only available for a few seconds before fatigue arises.

A shortening of conduction time across spinal centres was observed by Margaria and Gualtierotti (23). This decreased synaptic time involves substantial change of chemical processes taking place during excitation at the synaptic level. A short exhausting exercise which presumably may lead to a transient slight modification of the reflexes failed to result in statistically significant detectable changes. In long lasting exercise, changes in central time were significant.

Johnson (24) used pre-pubescent, pubsecent, and post-pubescent boys on two exercise trials on a bicycle ergometer under motivated and non-motivated states. There was variable reactions to the motivated exercise for all three classifications. Additional motivation tends to produce greater effort as evidenced by increases in pace and more acute adjustments

in heart rate and blood pressure but the additional effort did not necessarily produce greater total work output.

Ikai and Steinhaus (25) postulated that all performances of a short maximal limit were manifestations of acquired inhibitions. Inhibitions were eliminated by drugs, alcohol, and hypnosis. In the surprise shot case, the "orienting or focusing reflex" would be evoked or else it would act as an external inhibitory agent inhibiting the contraction response resulting in a lesser strength response than usually noticed. Accepting the view that such inhibition radiates over the cortex to involve many neural centres, the greater-than-normal pulls exerted when the shot preceded the pull by four to ten seconds would be explained by the inhibition of inhibiting mechanism in areas to which the shot-induced inhibition had, in the intervening time, spread. The above-normal strength in the second pull was found as long as sixty-four seconds after the shot. An alternate explanation assumes a weakening, with time, of the trace left by the shot:

> ...the process of internal inhibition is more labile (unstable) than that of stimulation and hence there can always be found such intensities of the new external inhibitory agent as are just sufficient to inhibit internal inhibitions but not strong enough to suppress the constant more stable process of the conditioned excitation. In this case, then, only disinhibition occurs... (26:137).

The observations presented by Jacobson (27) suggest that both the sensory and the motor responses of the organism to a sudden strong stimulus depend upon the preceding general state of muscular tonus; that the feeling of shock is weak or absent and the start is wanting or minimal where the individual is extremely relaxed.

Manzer (28) has subjects make fifty maximal muscular contractions each at fifteen second intervals on the Smedley hand dynamometer. The work was done concealed from all subjects. After each contraction from

the eleventh to the thirtieth inclusive, the subjects in the experimental groups were told by the experimenter the amount of work that they had done. Knowledge of output was followed by a prompt upward turn in the curve of muscular work. When knowledge of output was removed, no abrupt fall in the work curve occurred. Telling the subject that he will receive knowledge of his output, before the knowledge of his work score begins, resulted in a prompt upward turn in the work curve.

Fatigue Curves - Nature and Considerations

As applied to the fatigue problem, the exponential theory assumes that each contraction uses up a certain fraction of the initial work potential of the muscle, over and above that of the steady state which maintains the fatigue level. (29) This fraction will obviously be different if the rate of contraction is increased or decreased. The loss in work potential as between the first and second contraction represents as algebraic balance between the amount of energy used for the contraction and the amount functionally restored during the partial recovery that occurs between the two contractions.

The fatigue level is mathematically an asymptote. The theory assumes that this asymptote will be approached in a systematic and progressive manner, other things being equal. Change in motivation will cause irregularities in the curve. Also, changes in physiological conditions will cause departures from the simple exponential formula.

The normal muscle fatigue curve, as observed with a spring-loaded ergograph shows a simple exponential decay. The work done by any particular contraction, n, is given by the expression

$$C + A_0 e^{-k(n-1)}$$

where A_0 is the work done in the first contraction, k is the fatigue rate constant, and C is the fatigue level.

Clarke (30) used a dynamic type of fatiguing exercise on thirty subjects who were required to squeeze a spring-loaded hand ergograph maximally once every two seconds for six minutes. Mathematical fatigue curves fitted to the data obtained during exercise confirmed the results of previous investigators.

Vallerga (31) studied the influence of "perceptual" stimulus intensity on the speed of large muscle motor movement and, in a separate experiment, the influence on the force of muscular contraction. In general, the louder sounds produced faster arm movements and stronger contractions of the muscles. It was postulated that the greater perceived stimulus intensity results in stronger excitation of the pyramidal tracts and consequently more forceful muscular contractions.

The Learning Component in Repetitive Maximal Contractions

Freeman and Sharp (32) demonstrated the cyclical nature of action potentials from the biceps following weight-lifting, and added if such tensions are found to follow a cyclical course, they will constitute an important factor in any hypothetical explanation of such phenomena as the relative effectiveness of spaced and massed practice, the influence of presentation intervals in memorization, the effect of different intervals between periods of practice in experiments on retroactive inhibition, and, perhaps reminiscence.

Fleishman (33) made an attempt to produce differential effects of certain supplementary verbal motive incentive instructions upon performance of individuals of different ability levels. Subjects practiced on

self-paced complex psychomotor tasks for twenty, one minute trials. Only in the high ability subjects did the motivational instructions make a significant difference.

Whitley and Elliot (34) showed that individuals can learn how to exert force statically in an unfamiliar and fairly complex strength test. The influence of this learning effect can be determined providing that possible facilitative effects of training and inhibitory effects of fatigue are minimized.

Level of Activation

The behavior of the organism may be described as always occurring with some particular degree of intensity. The intensity of response is measurable in terms of the force of overt action or in changes in the internal processer associated with the release of energy. Duffy (35, 36) contends that for most purposes, a concept of intensity based on the measurement of internal processes appears to be a more useful psychological construct than one based on the force of overt response. Such a concept may be referred to as the level of activation, the degree of arousal, or the degree of energy mobilization, and describes a condition conceived to vary on a continuum from a low point of extreme effort or intense excitement.

The concept of activation holds further significance for psychology by virtue of the fact that variations in the degee of activation are usually accompanied by certain variations in overt response. The degree of activation appears to affect the speed, the intensity, and the coordination of responses. In general, the optimal degree of activation appears to be a moderate one; the curve which expresses the relationship between

activation and quality of performance being the form of an inverted "U."

The effect of any given degree of activation upon performance appears to vary with a number of factors, including the nature of the task to be performed (37) and certain characteristics of the individual such as the ability to inhibit and coordinate responses under a high degree of activation. Organismic interaction is the basic explanatory principle suggested (38) to account for the particular effects upon performance of various degrees of activation.

Eason and Branks (39) stated in their review that a considerable amount of data has been obtained which indicates that tension level reflects the amount of effort exerted during the performance of a task, and more generally the level of activation. Hence whether tension level will correlate positively or negatively with performance quality on a given task would be dependent on the factor or factors responsible for a change in activation level. An exception to this might be expected to occur only when the subject is already performing at his maximal skill level, resulting in possible decline in performance (40).

Duffy (41) hypothesized a two-dimensional behavior model in which behavior varies in both direction and intensity. From this model, one cannot tell from changes in tension level alone whether performance on a given task has improved or deteriorated since performance quality is also dependent upon the direction of the subject's behavioral activity at the time.

Klein (42) proposed that for every task there might exist optimal tension levels above or below which performance is impaired, and that the quality of performance in skilled motor tasks is dependent on the extent to which the performer manifests these optimal levels on any given occasion.

Malmo (43) suggested that muscular tension might function in a type of closed-loop feed-back circuit where tension states are induced experimentally or occur through learning; and these tension states in turn feed-back centrally, activate the reticular formation, and create activational level.

Hebb (44) related activation level and performance by psychologically naming the two different effects of a sensory event: the cue function, which guides behavior; and the arousal function, which is similar to Duffy's directional and activational aspects of behavior. Hebb explained the inverted U relationship between activation level and performance by considering the relation of cue function effectiveness to level of arousal. Assuming physiologically that cortical synaptic function is facilitated by the diffuse "bombardment" of the arousal system--the reticular activating system--when "bombardment" is at a low level, an increase will tend to maintain the concurrent cortical activity. Conversely, when arousal is at a high level, the greater "bombardment" may interfere with the delicate adjustments involved in cue function, perhaps by facilitating irrelevant responses. It was concluded that an optimal level of arousal exists for effective behavior.

Easterbrook (45) supported Hebb's theory of efficiency of cue utilization contending that whether a course of action is facilitated or disrupted by activation depends on its complexity and upon the range of cue utilization. Increased activation tends to interfere with the use of incidental cues, perhaps diminishing their phenomemal value and delaying reaction to them. However, it also tends to sharpen or concentrate action, and to perhaps enhance the phenomenal importance of central cues and expedite reaction to them.

From a different point of view, Adams (46) stated that an increase in electromyographic recordings during work must be due to a recruitment of additional motor units in order for a subject to sustain a particular work load. Unanswered was the question of how these new motor units become activated. Eason and Branks (39) suggested that the activation is cortically aroused and represents the strength of the subject's motivation in performing the task. In other words, as fatigue increases, activation arises to compensate for the subject's growing inability to cope with task demands.

To account for the fact that neuro-muscular control deteriorates when a task becomes progressively complex, Eason and White (49) postulated that when tension level becomes too great, implicit muscular responses, irrelevant to the task being performed, compete for motor units actively involved in the task, and thereby reduce the amount of control the performer is capable of maintaining.

Loudness and Stimulus Intensity

It might be expected that loudness increases in proportion to the intensity of the stimulus. According to Fechner's Law, loudness is proportional to the logarithm of the stimulus intensity, but this supposition proved to be far from the truth. If Fechner's Law held for loudness, any increase of one decibel should give the same increment of loudness regardless of the initial density. Actually an increase of one decibel in a strong tone sounds much greater than the same increase in a weak tone. Conversely, equal absolute increments of intensity sound greater in weak tones than in strong tones. By deduction then, the function relating loudness to stimulus intensity falls between the linear and the

logarithmic curve (3).

Stevens (48) found that on quantilative perceptual continua, such as loudness, equal stimulus ratios produce equal sensation ratios. This principle meant that the psychological magnitude (loudness) can be described as a power function of the physical magnitude (intensity). Further, an example of practical utility can be seen in the application of this power law to the problem of predicting the loudness of a complex noise from physical measurements made on the spectrum of sound (49, 50).

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CHAPTER III

METHODS AND PROCEDURES

Subjects

The sample consisted of eighty male physical education majors and required service program volunteers. Only right-handed subjects were used in this study.

Apparatus

A Stoelting, spring-loaded hand dynamometer was mounted on an unfixed base. The base was constructed so that no mechanical force, excepting that of the wrist flexors, could be applied to the hand dynamometer (see Figure 1). This procedure standardized the mechanical advantage for all subjects. The angle of the working arm was maintained at ninety degrees at the elbow. The non-working arm was rested parallel to the working arm approximately eight to ten inches away. Subjects remained seated throughout the testing. A blind was incorporated to ensure that the subject could view neither his results nor the experimenter. The experimenter could view the subject in a mirror located on the wall behind the subject. All instructions were pre-recorded to provide uniform conditions for each subject. The tape recorder was located three to four feet directly behind the subject to facilitate binaural hearing.

The Instructional Tape

Four separate instructional tapes were made, one for each treatment condition. The control tape was recorded at a baseline level of fifty decibels, seven hundred cycles per second. To ensure that each stimulus signal was identical, a loop of five second duration was made from the

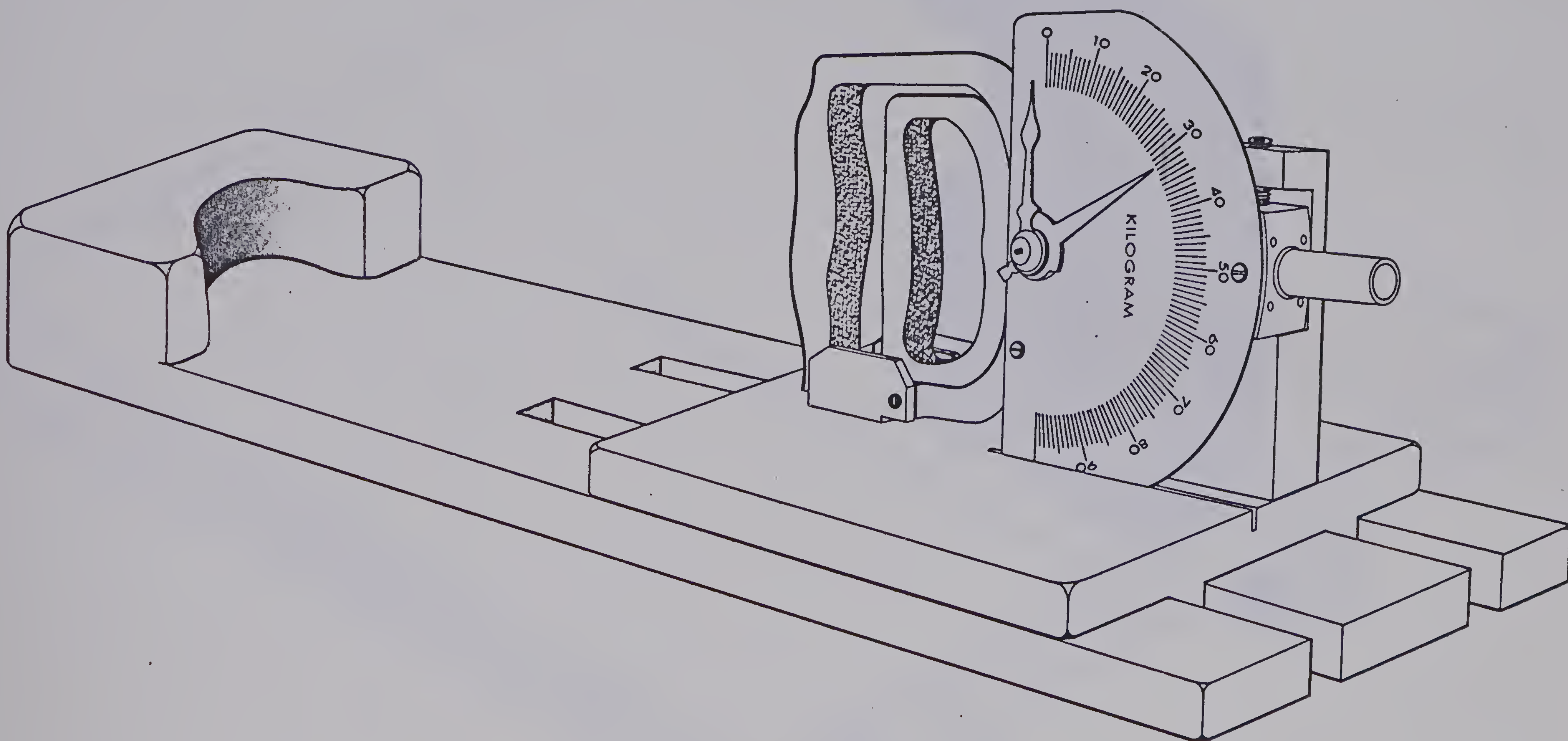

FIGURE 1: HAND DYNAMOMETER APPARATUS

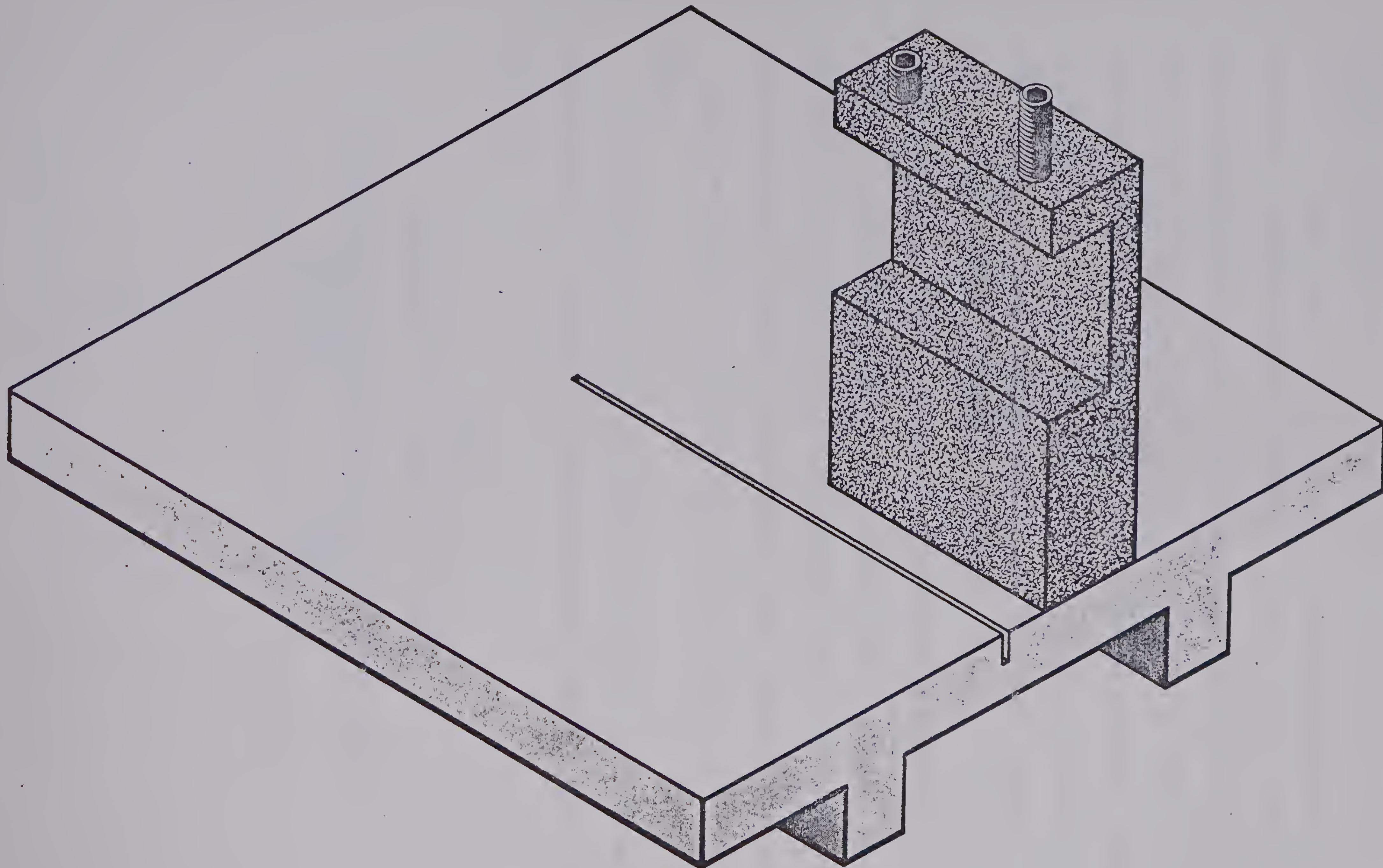

FIGURE 2: HAND DYNAMOMETER MOUNT

original instruction "pull." A warning blip of forty-five decibels, five-hundred cycles per second, one-quarter second duration was included in the loop, midway between the stimulus signal to "pull." Twenty-five such combinations were made for the control tape, excluding the blip before the first stimulus signal. For the experimental conditions, the control tape was duplicated, except that an increment of minus thirteen, plus thirteen, or plus twenty-six decibels was made from the baseline level for the sixteenth stimulus signal. In the actual testing, the intensity of the baseline level was increased to seventy-three decibels, the increment remaining constant for the experimental conditions.

The pre-test instructions (see Appendix E) were recorded, duplicated four times, and spliced onto the body section of the test tapes. These instructions were recorded at an intensity level ranging from sixty-eight to eighty-one decibels, and a frequency level of seven hundred cycles per second.

For corresponding levels of loudness see Table I. Table I demonstrates the relationship of intensity to loudness and was computed from a table in Hirsh (1).

TABLE I

RELATIONSHIP OF INTENSITY TO LOUDNESS

Intensity (Decibels)	Loudness (Sones)
40	1.0
60	6.0
73	15.9
86	38.8
99	81.3

Methods and Procedures

The random assignment to one of the four treatment groups was determined and the appropriate tape for the specific treatment group was placed on the tape recorder. The intensity level of the stimulus signal was checked by holding a sound-level meter (General Radio Company, Type 1551-C) in the approximate position of the subject's head and reading the deflection of the pointer. The subject was then brought into the room, seated in front of the hand dynamometer, and shown the working position. The subject was given three practice pulls to familiarize him with the apparatus. A two minute interlude was given between the practice pulls and the start of the actual test. During this time the experimenter gave the subject the cover story (see Appendix D). Upon completion of the test, the subject was debriefed as to the actual nature of the experiment.

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CHAPTER IV

RESULTS AND DISCUSSION

Statistical Analysis

A one-way analysis of variance was used to determine whether or not significant differences between the four test groups existed. The results of the analysis using the group difference scores of the four test groups are summarized in Tables II and III.

TABLE II

GROUP DIFFERENCE SCORES

Group	Number	Mean	Variance	Standard Deviation
1	20	1.0300	1.9633	1.4012
2	20	1.4200	5.6585	2.3780
3	20	0.9900	2.9957	1.7308
4	20	0.9700	1.6812	1.2966
Totals	80	1.1025	2.9550	1.7190

Key:
1 - Experimental Group (A) - Received 60 decibel "pull" on trial sixteen.
2 - Control Group - Received 73 decibel "pull" on all trials.
3 - Experimental Group (B) - Received 86 decibel "pull" on trial sixteen.
4 - Experimental Group (C) - Received 99 decibel "pull" on trial sixteen.

TABLE III

ANALYSIS OF VARIANCE

Source	Sums of Squares	Mean Squares	df	F	P
Groups	0.2725	0.91	3	0.30	0.83
Error	0.2337	3.07	76		

The one-way analysis of variance yielded no significant F value for the difference scores of the four test groups indicating that statistically there was no significant effect produced by the introduction of the independent variable in the three experimental conditions.

To add further power to the statistical treatment, a one-way analysis of covariance was employed on the mean scores of trials eleven to fifteen and sixteen to twenty for each subject. The results of the analysis on the adjusted means are summarized in Table IV.

TABLE IV

ANALYSIS OF COVARIANCE

Source	df	Mean Squares	Adjusted F	P
Groups	3	0.6596	2.167	0.884
Within	75	0.3043		

The one-way analysis of covariance failed to show a significant difference between the four test groups.

Discussion

The statistical analysis has indicated probability levels of p = 0.83 and p = 0.88 for the one-way analysis of variance and covariance respectively. Though neither of these levels can be considered statistically significant, it would be improper to deny a further analysis of the findings.

Hebb (1) and Easterbrook (2) proposed congruent theories of efficiency of cue utilization contending that whether a course of action is facilitated or disrupted by activation depends on its complexity and upon the range of cue utilization. Increased activation tends to interfere with the use of

incidental cues, perhaps diminishing their phenomenal value and delaying reaction to them. However, it also tends to sharpen or concentrate action, and to perhaps enhance the phenomenal importance of central cues and expediate reaction to them. Relating the fatigue problem to this theory, Eason and Branks (3) suggested that as fatigue increases, activation arises to compensate for the subject's growing inability to cope with task demands. Eason and White (4) postulated that when tension level becomes too great, implicit muscular responses, irrelevant to the task being performed, compete for motor unit actively involved in the task, and thereby reduce the amount of control the performer is capable of maintaining.

Fatigue and Muscular Tension. There is general agreement regarding an optimal tension level required for different tasks, but less agreement regarding the other correlates which affect performance. Eason and Branks (3) have attributed the factor or factors responsible for a change in activation level to the occurence of both positive and negative correlations between tension level and performance, the exception being when a person is already performing at a maximal level. Then, a possible decline in performance may result.

Other factors affecting the facilitation of an activity are the locus of the facilitating activity (5), the amount or intensity of the facilitating activity (6, 7), and the time relations existing between the onset of the facilitating activity and the performance under observation (5, 6, 8). Each of these factors was considered in establishing the experimental setting and procedures.

Psychophysiologic Phenomena. One factor which was impossible to standardize was the pre-test motivational level for each subject. In a

test involving a voluntary maximal performance, it is best to use a homogeneous group which would be characterized by an inherent, high interest in the project (9). Randomly sampling males from both the physical education and required physical education student populations violated this consideration.

Margaria and Gualtierotti (10) observed a shortening of conduction time across spinal centres in long lasting exercise, while short exhausting exercise failed to induce detectable changes. This seemingly supports increasing the duration of the working time before applying the facilitating agent.

Johnson (11), using extrinsic motivation to induce greater effort, found increases in pace and more acute adjustments in heart rate and blood pressure in subjects riding on a bicycle ergometer. The additional effort did not necessarily produce a greater work output. The incorporation of such a second-order measure would have revealed whether or not a similar situation existed in the test used in this study.

<u>The Startle Response</u>. Ikai and Steinhaus (6) found that the introduction of a surprise stimulus could evoke the startle response and act as an external inhibitory agent inhibiting the contraction response, resulting in a lesser strength response than usually noticed. In some cases though, the activation of the orienting or focusing reflex results in inhibition radiating over the cortex to involve many neural centres, with greater-than-normal work output occurring. This was explained as the inhibition of inhibiting mechanisms in areas to which the stimulus-induced inhibition had spread.

Jacobson (7) suggested that the startle response is minimal or absent in cases where the individual is extremely relaxed. Vallerga (12) noted

that louder sounds produced stronger contractions of the muscles specifically involved in the task being done. Possibly the greater perceived stimulus intensity resulted in stronger excitation of the pyramidal tracts and consequently more forceful muscular contractions. This startle response was especially noticeable in the fatigue curves for experimental groups three and four.

The Fatigue Curves. The fatigue curves derived from the grouped data were consistent with the literature in that they displayed an exponential decay. Irregularities due to changes in motivation were in evidence in portions of the curves for groups three and four. The control curve had a noticeably higher initial score but decayed in an exponential fashion.

All of the experimental group curves appeared to illustrate less decay than the control group curve for the portion from trials sixteen to twenty-five, though this was not borne out statistically. This may be attributed to the difference of the initial response level of the control group curve. Figure 3 gives the mean scores for all groups.

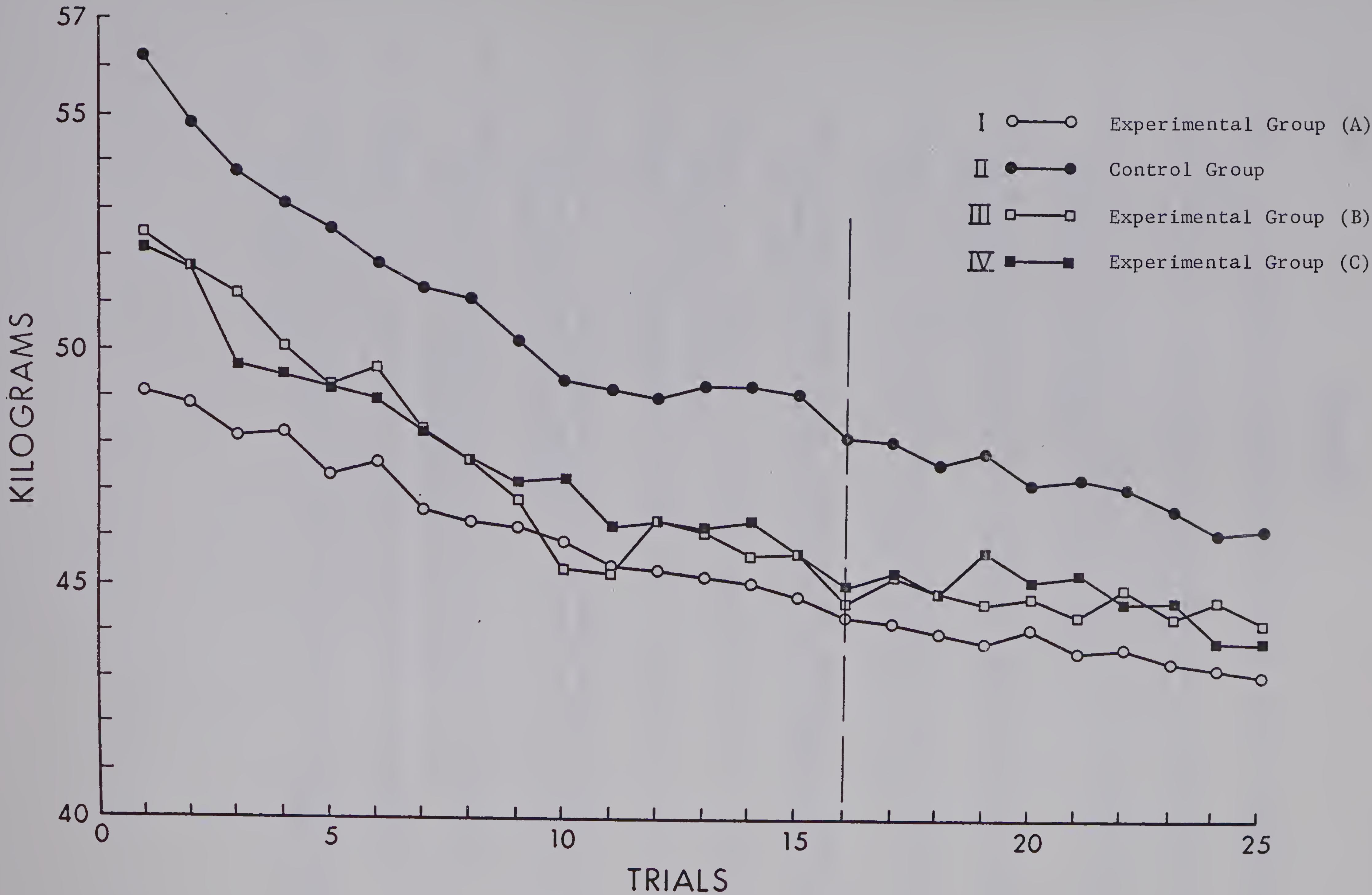

FIGURE 3: FATIGUE CURVES FOR ALL GROUPS

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CHAPTER V

SUMMARY AND CONCLUSION

Summary

The purpose of this study was to determine the effect of stimulus intensity on the fatigue curve for voluntary maximal grip strength. A sub-problem was to find which degree of intensity change would be most effective in inducing the change.

Eighty right-handed male physical education majors and required service program volunteers in attendance at The University of Alberta were randomly assigned to one of four groups.

Each subject received only one test on one treatment condition. Group one received twenty-four stimulus signals at a constant level of seventy-three decibels, except on trial sixteen when the stimulus signal was decreased to sixty decibels. Group two was the control group and had twenty-five identical stimulus signals at seventy-three decibels. Groups three and four were given instructions identical to Group one except they received a stimulus signal of eighty-six and ninety-nine decibels respectively on trial sixteen.

Analyses of variance and covariance on the difference of mean scores of trials eleven to fifteen as compared to trials sixteen to twenty failed to yield a significant F value.

Conclusion

On the basis of the analysis of the data in this study, the following conclusion is justifiable:

No significant differences existed between any of the four treatment groups.

Recommendations

It is recommended that any future experimentation along lines of inquiry similar to this study incorporate the following suggestions:

(a) Use a group which would be more homogeneous on strength of grip as well as specific interest in the study.

(b) Include a second or third measureable parameter such as measures of heart rate, blood pressure, or electromyographic activity.

Some suggestions for extended research are:

(a) The motivating stimulus signal could differ from the other instructional cues in sensory modality as well as intensity.

(b) The number of trials could be increased to fifty from the twenty-five used in this study.

(c) The placement of the motivating stimulus could be changed.

(d) The number of times that the motivating stimulus signal is introduced could be changed.

(e) A comparison could be made on the difference in reaction of a highly trained individual as opposed to an untrained individual to the motivating agent.

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APPENDIX A

RAW DATA

GROUP I

GRIP STRENGTH SCORES IN KILOGRAMS

Trial	Subject									
	1	2	3	4	5	6	7	8	9	10
1	53	44	57	47	56	51	46	46	49	44
2	52	44	57	44	57	50	46	53	50	45
3	52	50	55	43	56	50	42	54	44	43
4	52	53	54	46	55	50	45	54	50	41
5	50	51	53	45	54	50	43	54	49	42
6	50	51	53	44	53	49	42	53	50	42
7	49	54	52	43	51	49	41	52	49	42
8	47	52	52	47	51	49	41	51	49	40
9	48	51	52	46	51	50	40	51	49	39
10	48	52	52	48	54	49	40	49	49	38
11	48	53	50	45	53	49	41	49	49	36
12	46	52	49	46	50	48	42	49	49	38
13	45	53	48	48	53	49	41	52	49	39
14	46	50	49	45	51	47	40	51	48	38
15	48	49	48	47	52	46	39	52	46	39
16	45	49	46	49	51	46	37	51	47	40
17	45	49	46	49	51	46	37	51	47	40
18	45	50	48	45	53	44	40	51	47	38
19	44	51	45	44	51	47	39	49	47	41
20	45	49	44	44	53	47	41	51	49	41
21	46	48	47	44	51	46	33	51	48	38
22	45	51	44	42	52	46	39	52	47	39
23	43	49	42	42	51	44	35	49	47	40
24	44	49	46	42	54	45	35	48	45	36
25	44	50	45	43	54	44	38	49	47	35

Trial	Subject									
	11	12	13	14	15	16	17	18	19	20
1	51	35	41	49	50	54	57	49	53	49
2	49	43	38	46	49	54	54	47	53	48
3	48	39	43	47	50	51	51	46	49	46
4	48	39	38	45	51	55	50	45	48	48
5	48	38	37	44	50	53	51	44	49	44
6	48	37	43	45	50	53	50	43	51	46
7	46	36	41	45	47	51	49	41	47	47
8	46	36	38	44	48	51	50	40	48	48
9	44	36	43	43	48	53	49	41	48	43
10	43	34	39	43	46	53	48	42	47	45
11	45	35	36	40	48	54	48	40	47	43
12	45	37	37	40	47	53	47	42	48	43
13	45	32	41	38	48	51	43	40	46	44
14	44	37	37	41	46	52	47	41	48	43
15	44	33	35	40	46	53	45	40	48	43
16	42	33	36	40	47	54	45	39	45	42
17	43	33	37	40	46	51	43	39	50	42
18	39	37	36	38	45	49	43	39	51	42
19	41	38	32	39	44	48	44	41	51	41
20	43	36	37	38	44	48	43	40	48	41
21	42	34	36	36	43	51	46	41	46	44
22	41	30	37	37	45	49	46	41	47	43
23	41	37	35	33	43	51	43	41	49	44
24	41	34	35	38	45	49	41	41	46	41
25	43	34	37	38	44	51	45	42	45	43

GROUP II

GRIP STRENGTH SCORES IN KILOGRAMS

Trial	Subject									
	1	2	3	4	5	6	7	8	9	10
1	65	72	58	54	64	61	44	51	68	50
2	64	66	55	53	63	60	49	51	66	48
3	61	64	57	52	61	57	50	51	64	48
4	59	65	56	51	63	56	48	51	63	48
5	59	64	56	50	62	55	51	49	61	46
6	59	63	56	50	62	55	48	50	60	47
7	57	60	56	47	62	53	47	51	61	46
8	55	60	55	46	63	54	49	48	61	46
9	56	60	55	45	61	54	49	49	60	45
10	55	56	55	44	53	55	47	49	63	46
11	53	56	51	46	58	53	48	50	62	45
12	52	56	53	48	52	52	45	49	63	45
13	53	57	53	45	58	52	47	48	61	43
14	52	56	55	49	58	53	47	47	62	44
15	58	56	51	44	56	54	48	46	60	44
16	57	55	53	44	58	54	46	47	59	45
17	58	51	59	43	56	51	45	47	58	43
18	55	52	60	43	56	51	47	43	58	43
19	52	53	60	43	56	50	46	46	60	45
20	54	51	60	40	52	51	48	43	57	45
21	52	49	63	41	51	50	51	46	56	44
22	51	49	61	42	54	48	49	48	57	44
23	50	46	58	42	52	50	50	47	59	44
24	51	48	58	42	53	50	49	47	57	44
25	50	47	61	41	53	51	49	47	57	43

Trial	Subject									
	11	12	13	14	15	16	17	18	19	20
1	59	56	51	56	51	46	36	69	59	55
2	57	50	48	50	51	47	36	67	61	56
3	56	47	49	54	48	43	37	65	58	54
4	56	46	48	53	48	41	37	63	59	52
5	55	47	47	52	46	43	37	62	58	54
6	56	45	42	50	45	43	38	61	57	51
7	56	45	47	50	45	41	35	61	56	52
8	56	44	44	49	46	39	35	59	57	55
9	53	43	40	48	45	38	35	59	56	53
10	55	43	42	46	43	37	33	56	56	54
11	55	44	40	48	44	38	31	56	54	52
12	54	46	48	45	44	36	30	56	54	52
13	56	46	46	45	43	36	33	59	53	53
14	55	45	45	48	44	32	31	60	51	53
15	55	45	47	46	43	30	32	59	52	55
16	54	43	43	42	43	30	28	55	53	55
17	54	43	44	48	42	33	27	54	51	54
18	54	44	43	45	41	30	30	51	51	55
19	54	43	47	45	39	31	29	54	52	52
20	54	43	44	45	42	29	29	51	52	53
21	53	42	43	45	43	31	29	51	53	53
22	53	44	43	43	43	28	27	50	53	54
23	52	42	42	43	43	28	29	53	48	53
24	51	42	41	44	40	22	28	51	50	53
25	50	42	39	43	41	28	28	52	50	52

GROUP III

GRIP STRENGTH SCORES IN KILOGRAMS

Trial	Subject									
	1	2	3	4	5	6	7	8	9	10
1	60	58	59	49	56	52	58	37	48	44
2	58	60	59	52	52	57	56	35	43	46
3	59	60	58	54	54	54	55	36	40	43
4	55	59	57	51	48	55	54	37	40	44
5	56	58	55	50	45	54	55	37	38	41
6	56	57	54	51	47	54	53	36	41	42
7	55	55	55	48	48	51	53	37	41	39
8	53	54	53	47	50	52	53	37	41	36
9	55	51	54	45	43	50	52	36	41	34
10	51	52	53	44	43	47	51	35	41	31
11	52	47	50	44	43	46	51	36	43	32
12	52	51	57	43	44	48	53	35	46	36
13	51	50	57	43	39	51	50	36	45	36
14	52	50	56	44	35	50	49	35	42	36
15	50	51	56	44	39	50	47	36	44	37
16	50	46	54	43	43	48	48	37	45	33
17	49	47	55	45	42	55	46	37	44	31
18	49	46	53	39	41	55	45	36	44	33
19	50	47	54	43	38	54	45	34	41	28
20	48	48	53	44	38	51	44	37	44	33
21	49	49	52	43	42	51	45	37	43	30
22	49	50	51	45	38	51	45	37	40	33
23	48	53	50	45	38	50	41	37	43	30
24	46	43	51	43	37	52	44	38	42	32
25	46	43	52	45	37	51	44	38	42	30

Trial	Subject									
	11	12	13	14	15	16	17	18	19	20
1	56	62	52	52	43	46	55	45	66	52
2	55	64	49	54	45	43	50	43	64	51
3	53	64	44	52	43	44	48	44	66	54
4	50	61	45	54	40	43	48	43	65	53
5	50	61	40	53	43	41	50	42	64	53
6	48	63	45	52	47	43	48	41	61	52
7	47	61	42	52	44	38	49	40	60	53
8	47	58	41	52	44	38	49	38	58	53
9	45	60	42	51	43	38	48	37	59	53
10	43	60	43	50	39	36	48	34	55	52
11	43	60	41	51	37	39	48	36	57	51
12	43	61	43	51	34	36	48	36	58	53
13	42	60	38	50	42	39	49	33	58	54
14	43	58	40	49	39	38	48	33	56	58
15	43	53	40	50	41	37	48	37	54	56
16	42	59	37	50	33	37	46	31	53	56
17	43	58	38	49	37	34	48	36	55	56
18	41	58	42	48	40	38	47	36	53	55
19	42	56	40	48	41	38	48	36	55	54
20	42	57	41	47	40	37	49	35	55	53
21	42	55	40	48	38	34	48	37	54	52
22	42	51	41	48	42	34	49	36	54	64
23	42	50	43	47	41	37	47	36	53	58
24	42	56	44	46	42	36	49	35	57	59
25	42	54	42	47	41	36	46	35	53	58

GROUP IV

GRIP STRENGTH SCORES IN KILOGRAMS

Trial	Subject									
	1	2	3	4	5	6	7	8	9	10
1	52	53	48	53	52	57	56	44	51	47
2	51	52	50	53	53	54	54	43	52	50
3	48	51	49	54	51	51	53	43	50	44
4	48	50	49	53	51	51	51	44	51	48
5	52	49	49	51	53	50	51	44	48	48
6	50	49	49	52	50	48	51	43	50	46
7	50	49	48	50	46	48	50	44	49	46
8	48	49	48	51	49	46	50	43	49	47
9	48	48	48	50	47	47	49	41	49	49
10	47	49	47	51	49	45	49	42	48	47
11	50	46	44	50	48	45	48	42	51	44
12	51	45	45	50	46	46	47	41	50	46
13	51	46	43	49	47	47	47	41	51	45
14	49	47	45	49	50	47	50	39	48	44
15	49	44	42	50	48	47	45	40	47	42
16	48	44	41	46	45	44	46	40	48	44
17	48	45	41	46	47	45	45	39	47	43
18	49	45	43	48	42	45	48	39	47	45
19	51	45	43	46	45	47	49	39	49	45
20	50	45	41	44	44	45	48	40	46	42
21	50	44	39	48	43	46	48	40	48	45
22	50	44	36	46	43	45	49	38	46	43
23	52	44	40	47	43	46	49	40	45	43
24	54	46	38	45	43	43	47	38	43	41
25	45	50	38	45	42	44	47	40	47	38

Trial	Subject									
	11	12	13	14	15	16	17	18	19	20
1	55	54	61	48	50	58	49	47	54	55
2	53	53	61	46	50	54	49	47	55	54
3	51	46	62	45	47	52	48	39	56	54
4	51	49	58	43	46	51	48	42	54	52
5	52	51	59	44	46	51	46	42	52	48
6	52	48	58	44	46	50	45	47	54	48
7	50	52	56	44	45	49	46	43	56	46
8	47	48	55	43	47	49	45	41	51	47
9	48	47	54	44	49	49	43	36	51	48
10	45	47	56	43	50	51	44	42	52	43
11	45	41	56	41	48	50	44	40	48	44
12	44	48	56	42	46	48	43	41	50	43
13	44	44	56	43	49	48	41	45	48	40
14	46	45	56	41	51	43	44	44	48	42
15	46	46	56	40	48	45	43	40	50	43
16	43	45	54	41	50	48	43	42	50	38
17	44	49	56	40	47	47	44	43	47	42
18	44	44	53	39	46	46	45	41	49	41
19	45	45	55	41	53	46	43	41	48	38
20	45	46	54	41	48	50	45	43	46	39
21	43	47	52	41	48	51	44	38	48	42
22	45	44	53	41	47	49	45	41	46	40
23	42	44	53	41	46	49	44	41	47	37
24	42	45	52	40	44	48	45	39	45	39
25	43	42	52	41	47	45	45	39	47	40

APPENDIX B

GROUP AVERAGE SCORES

GROUP AVERAGE SCORES

Trial	Group			
	I	II	III	IV
1	49.05	56.25	52.50	52.20
2	48.95	54.90	51.80	51.70
3	48.20	53.80	51.25	49.70
4	48.35	53.15	50.10	49.50
5	47.45	52.65	49.30	49.30
6	47.65	51.90	49.60	49.00
7	46.60	51.40	48.40	48.35
8	46.40	51.05	47.70	47.75
9	46.25	50.20	46.85	47.25
10	45.95	49.40	45.40	47.35
11	45.45	49.20	45.35	46.25
12	45.40	49.00	46.40	46.40
13	45.25	49.35	46.15	46.25
14	45.05	49.35	45.55	46.40
15	44.85	49.05	45.65	45.55
16	44.45	48.20	44.55	45.00
17	44.25	48.05	45.25	45.25
18	44.00	47.60	44.95	44.95
19	43.85	47.85	44.60	45.70
20	44.10	47.15	44.80	45.10
21	43.55	47.30	44.45	44.25
22	43.65	47.05	45.00	44.25
23	42.95	46.55	44.45	44.65
24	42.75	46.05	44.70	43.85
25	43.55	46.20	44.25	43.85

APPENDIX C

GROUP DIFFERENCE SCORES

GROUP DIFFERENCE SCORES

Subject	Group			
	I	II	III	IV
1	+1.0	-1.6	+2.2	+0.8
2	+2.0	+3.8	+3.0	+0.8
3	+2.6	-5.8	+1.4	+2.0
4	+0.6	+3.8	+0.8	+3.6
5	+0.2	+0.8	-0.4	+3.2
6	+1.8	+1.4	-3.6	+1.2
7	+1.4	+0.6	+4.4	+0.2
8	-0.8	+2.8	-0.6	+1.2
9	+1.2	+3.2	+0.4	+2.0
10	-1.2	+0.0	+3.8	+0.4
11	+3.0	+1.0	+0.8	+0.8
12	-0.6	+2.0	+0.8	-1.0
13	+1.6	+1.0	+0.8	+1.6
14	+0.8	+1.4	+1.8	+1.0
15	+1.8	+2.2	+0.4	-0.4
16	+2.6	+3.8	+1.0	-0.6
17	+2.4	+2.8	+0.6	-1.0
18	+1.0	+5.0	+0.2	+0.0
19	-2.4	+1.0	+2.4	+0.8
20	+1.6	-0.8	-0.4	+2.8

APPENDIX D

COVER STORY

COVER STORY

This experiment is designed to compare Physical Education majors to other university-aged males on the task of grip strength. The grip strength task is being employed since it is considered the best simple prediction of total body strength. Each subject is to make twenty-five maximal grip strength contractions in order to induce a fatigue state.

The general hypothesis is based on the premise that Physical Education students are generally more active year round, participating in several different sports. Hence, on the average, they should be more fit. Group comparisons should tend to show that the Physical Education group base a higher mean grip strength score as well as being less prone to fatigue.

APPENDIX E

PRE-TEST INSTRUCTIONS

PRE-TEST INSTRUCTIONS

This study concerns the fatiguability of Physical Education men as compared to other university-age males. You will be required to make twenty-five maximal grip strength contractions on the hand dynamometer in front of you. It is essential that each contraction you make is a maximal contraction. You make each contraction on the instruction "pull." You will receive the twenty-five instructions to "pull" spaced at five second intervals. You will also hear a warning blip about two to three seconds before you hear the instruction "pull." This is your cue to get ready. Now reassume your working position. Remember that the blip is just a warning or preparation signal. Pull only on the instruction "pull." Your full cooperation is essential. Your first "pull" will come five seconds from now.